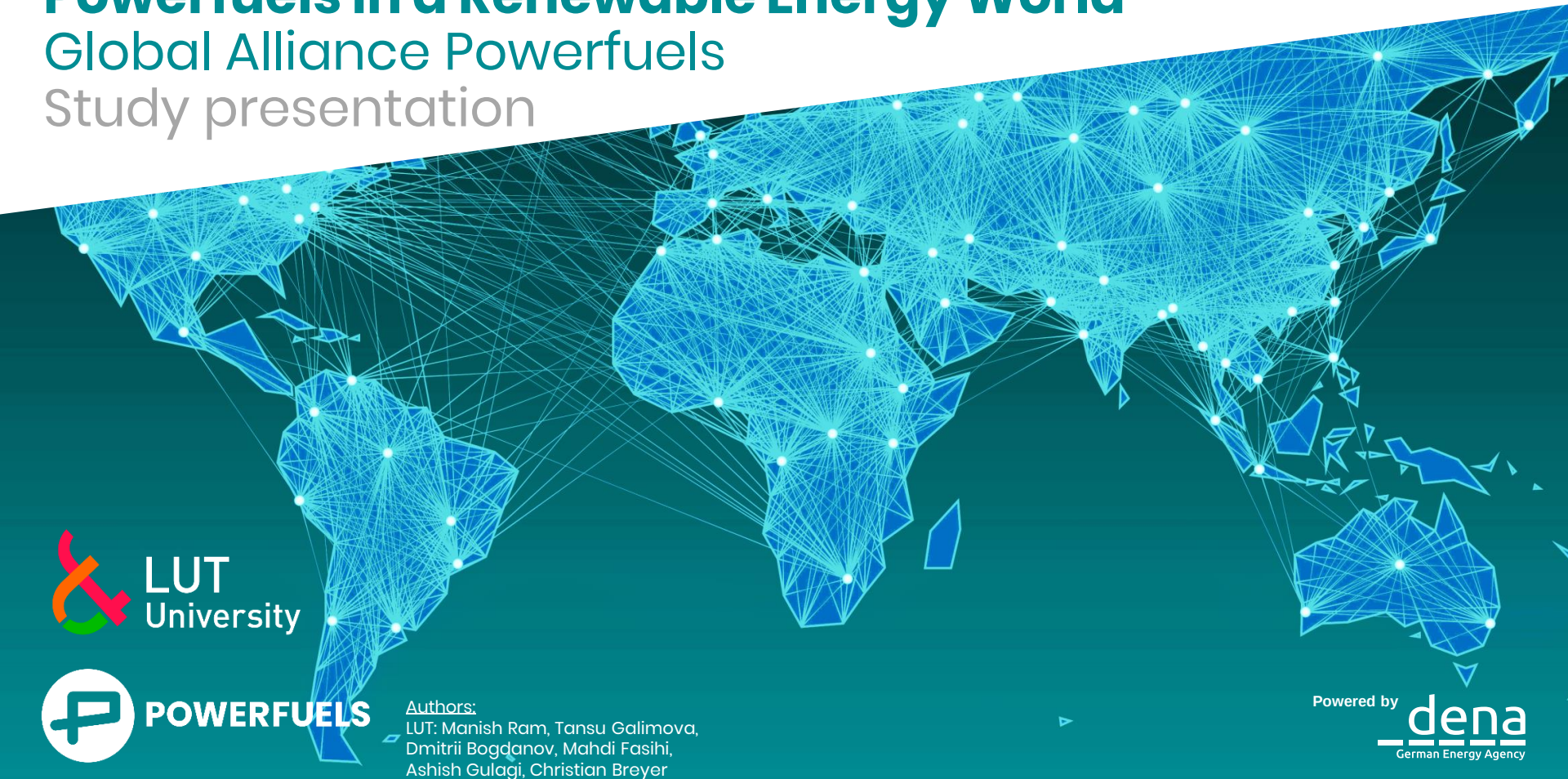
Powerfuels in a Renewable Energy World

Global Alliance Powerfuels

Study presentation



LUT University

POWERFUELS

Authors:
LUT: Manish Ram, Tansu Galimova, Dmitrii Bogdanov, Mahdi Fasihi, Ashish Gulagi, Christian Breyer
dena: Matteo Micheli, Kilian Crone

Powered by dena German Energy Agency

Presenters and Agenda

1 Welcome and introduction
Mr. Stefan Siegemund
Director, Sustainable Mobility and Alternative Energy Sources, dena

2 Background and methods
Prof. Dr. Christian Breyer
Professor for Solar Economy, LUT University

3 Key messages and perspective of the German Energy-Agency
Mr. Matteo Micheli, *Expert power-to-X technologies, dena*
Mr. Christoph Jugel, *Director, Energy Systems, dena*

4 Q&A and outlook




LUT University

Global Alliance Powerfuels – What we do

An initiative coordinated by the German Energy Agency

Advocacy & Communication

Raise awareness and acceptance of powerfuels as missing link to reaching global climate targets

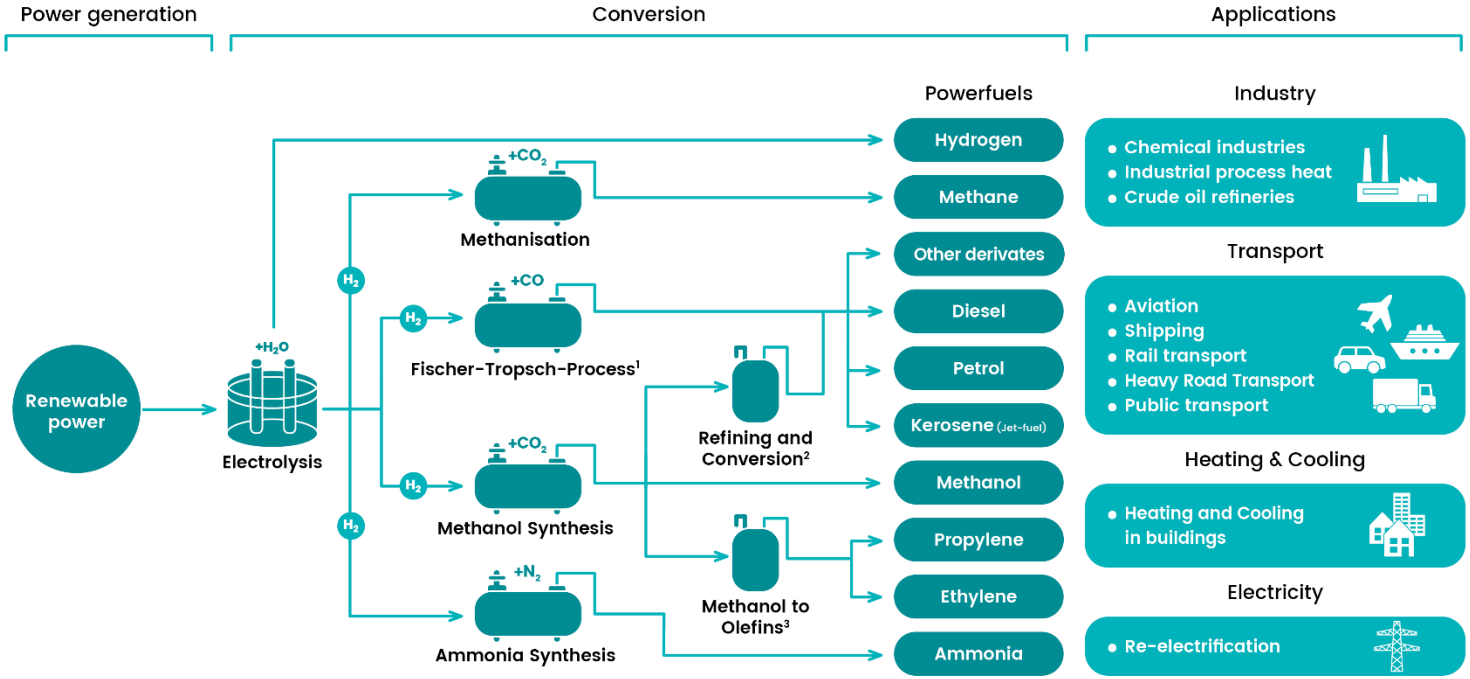
Policy & Regulation

Support the enhancement of regulatory frameworks with a focus on Europe as demand region

Global Project Development

Stimulate project development to globally enable production capacities

What are powerfuels?



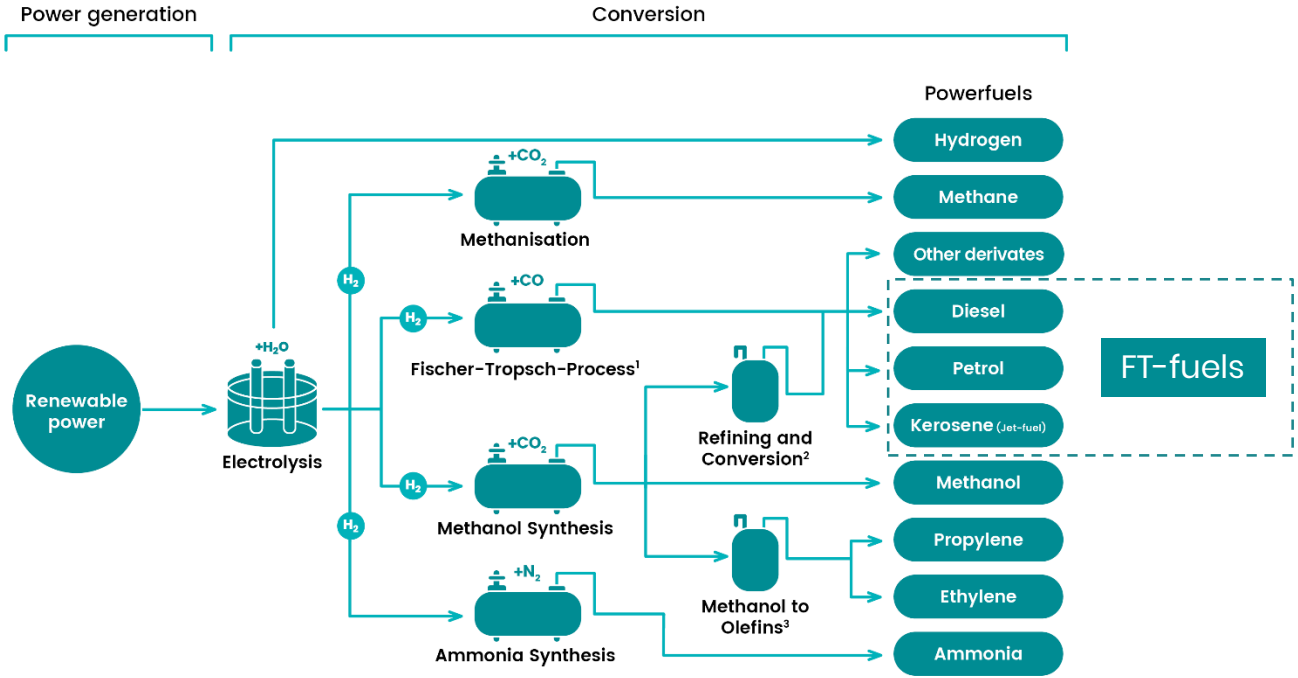
1 Includes: Fischer-Tropsch synthesis, hydrocracking, isomerization and distillation.

2 Includes: DME/OME synthesis, olefin synthesis, oligomerisation and hydrotrating.

3 Methanol-to-olefins process.

LUT University

What are powerfuels?



❶ Includes: Fischer-Tropsch synthesis, hydrocracking, isomerization and distillation.

❷ Includes: DME/OME synthesis, olefin synthesis, oligomerisation and hydrotrating.

❸ Methanol-to-olefins

LUT University

Our global network

Our members

Our partners

LUT University

Background and methods

Research questions

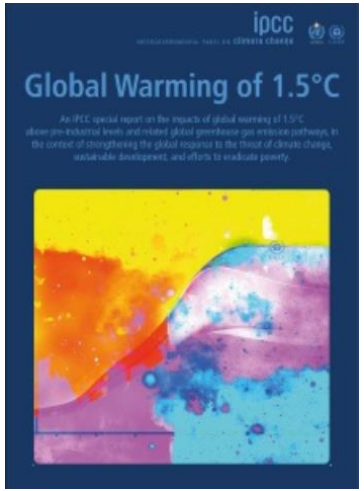
What is the role of powerfuels in a Renewable Energy World ?

- What are the **relevant powerfuels**?
- What is the **global cost structure** of these powerfuels?
- What sort of **import** and **export** structure works globally?
- What is the impact on powerfuels from **global trade**?
- What are the **shares of point sources vs DAC** for carbon supply for hydrocarbons production?

LUT University

Background of Study
Climate Frameworks and modeling implications

European Green Deal	Paris Agreement (well below 2°C)	Modeling implications



- (Net) zero greenhouse gas (GHG) emissions by 2050 are mandatory
- Negative GHG emissions are costly, risky, with unclear responsibilities.
- Thus, zero GHG emissions is the real target for the energy system
- This implies in particular GHG emission neutral powerfuels (fuels for transport, chemicals for industry)

Background of Study
Room for improvement in existing works

Source	final energy fuel shares in 2050 in %			
	fossil fuels	biofuel	powerfuels	electricity
This work	0	1	63	35
Greenpeace [E]R[73]	29	14	20	38
Greenpeace [E]R adv.[73]	0	14	35	51
Teske, 1.5 °C[74]	0	16	36	48
Teske, 2 °C[74]	0	25	29	46
Jacobson et al.[75]	0	0	33	67
Löffler et al.[76]	0	15	44	41
Pursiheimo et al.[77]	0	30	33	37
García-Olivares et al.[78]	n/a	n/a	n/a	n/a
WWF[79]/Deng et al.[80]	0	74	0	26
World Energy Council[81]	62	12	9	17

*presented numbers apply to the transport sector only
(From the presented, upcoming study)

Considered gaps from existing works

- Powerfuels in major energy studies are still very often limited to hydrogen only
- RE-based chemicals are not yet part of any known global study
- Models lack inclusion of powerfuels
- Green Deal and ambitious IPCC targets are not yet well reflected in most studies

Unique Features of the Study

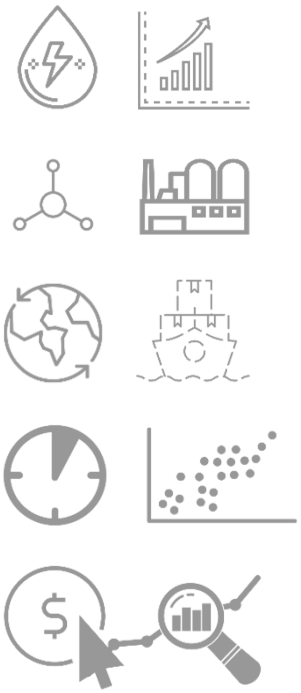
Covering the **fuel demand by powerfuels** in a sustainable economy

Chemical industry is fully **considered** within powerfuels demand

Global trade of powerfuels enabled for existing shipping options

Full hourly resolution of analyses based on 145 regions

Latest cost insights applied for all key technologies



LUT University

Applied Methods

Step 1
Framing, demand, fuels/chemicals

Fully sustainable energy system by 2050

LUT reports as basis for powerfuels demand and cost structure

Step 2
Cost structures and regional structuring

Years 2030, 2040, 2050 are considered for 145 regions globally, aggregated to 92 regions

LUT reports as basis for latest cost levels of solar PV, battery, CO_2 DAC

Full hourly modeling, PV/Wind shares, operation modes of electrolysers, DAC, etc.

Step 3
Global trading

All 92 regions are grouped into importers, exporters and neutral

Relative export shares estimated as a function of export attractiveness, cost attractiveness, available area

Import demand obtained as a function of relative cost levels and import shares of 0...100%

Step 4
Results analysis

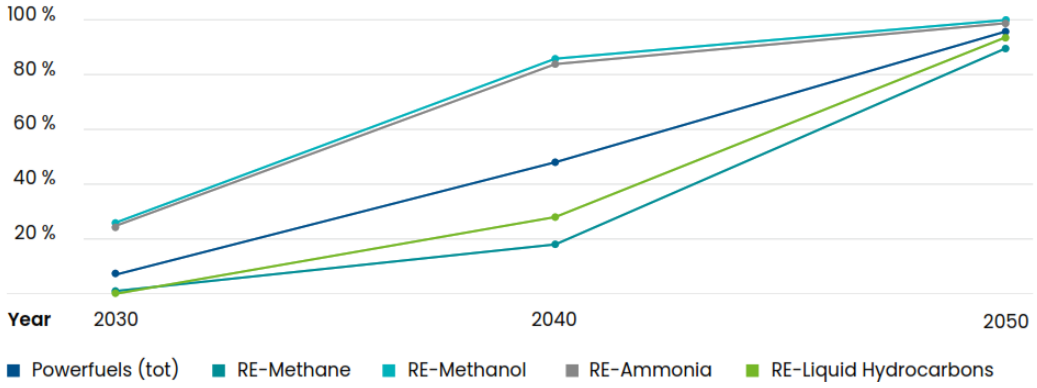
Global market for powerfuels: pre-trade and post-trade, volumes, values, trends over time and regions

LUT University

Main Assumptions: energy transition pathway, powerfuels share across sectors and applications

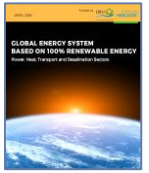
- Carbon neutral global energy system by 2050
  - Development of powerfuels shares in the transport sector according to LUT/EWG study
  - Development of powerfuels shares in chemical industry according to progressive assumptions
  - Energy demand and underlying assumptions aligned with IEA World Energy Outlook
- Very high levels of direct electrification
- Use of biofuels limited at 2020 levels due to sustainability constraints

Global shares of demand for fuels and chemicals covered by powerfuels from 2030 to 2050



Referenced LUT studies

link to report



link to report

LUT University

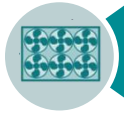
Technical and financial assumptions of energy system technologies used in the energy transition

Solar PV: CAPEX according to European Technology and Innovation Platform Photovoltaics (ETIP-PV)

Wind: CAPEX based on conservative assumptions due to lack of transparent information provided by wind industry

Battery: CAPEX assumptions confirmed by major industry players

Water electrolysis: CAPEX assumptions based on numbers communicated by industry players



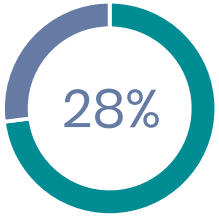
CO_2 DAC: conservative CAPEX assumptions, based on numbers communicated by industry players

LUT University

Key findings

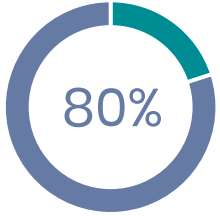
Powerfuels and DAC play an important role in a carbon neutral global energy system

43,200 TWh
Final energy demand covered by powerfuels in 2050



of global final energy consumption 2050

6,000 Mt
CO_2 demand for powerfuels production in 2050



of which is supplied by DAC, 20% from point sources

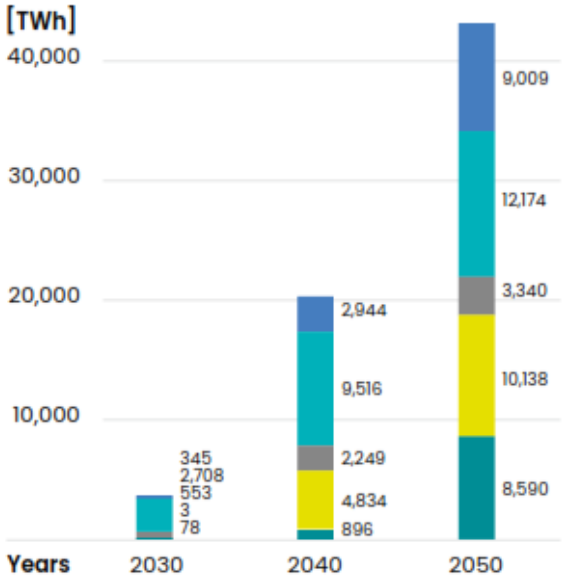
18,000 b€
Investments required until 2050

Close to the cost of sustaining oil and natural gas demand at current levels in same timeframe.
upstream capital expenditures = approx. 17,500 b€

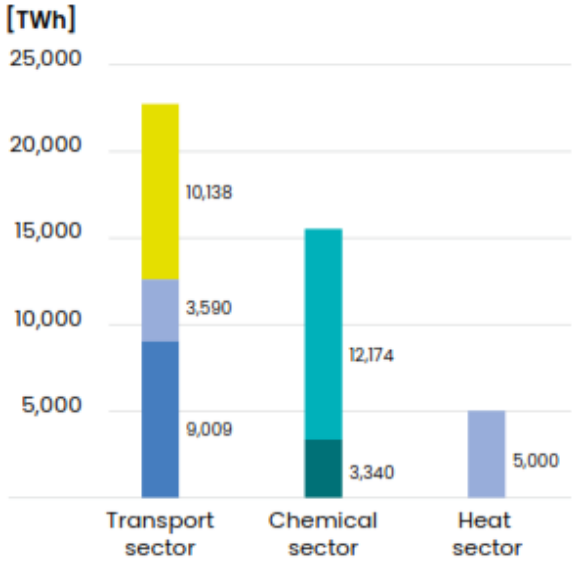
LUT University

All types of powerfuels play a dominant role 2030–2050
With different shares in different sectors

Global powerfuels demand by year



Global powerfuels demand by sector in 2050



Legend

- SNG
- FT-fuels
- Hydrogen
- RE-Ammonia
- RE-Methanol

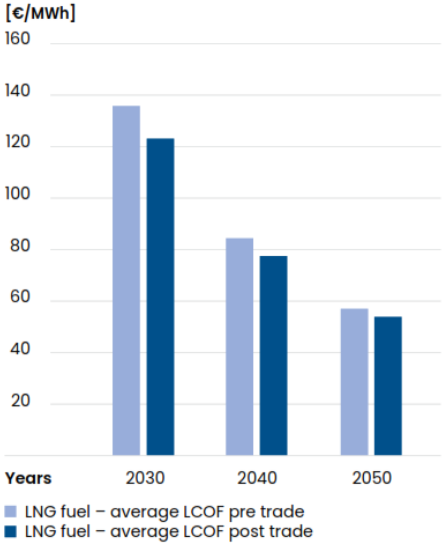
Transport sector 2050	23,000 TWh
Chemical sector 2050	15,500 TWh
Heat sector 2050	5,000 TWh

LUT University

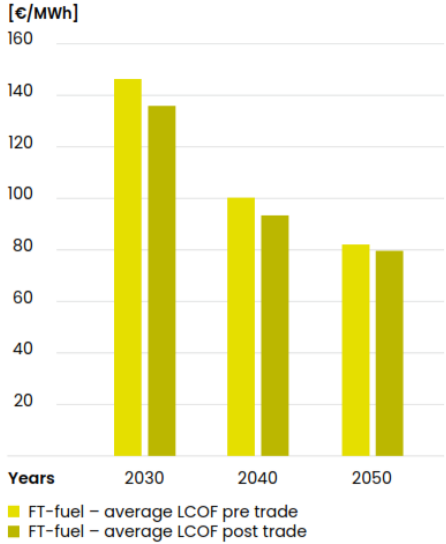
Costs of powerfuels decline steadily until 2050

Levelised cost of globally traded powerfuels

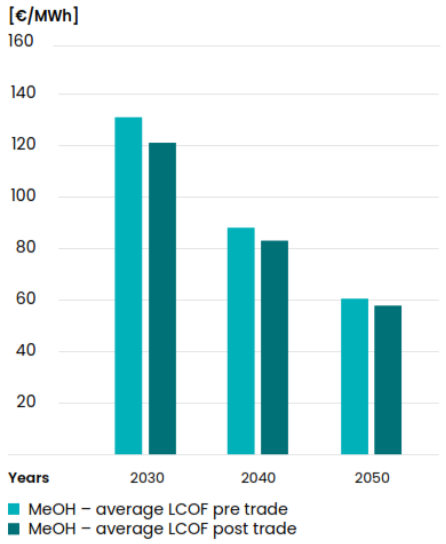
LNG/SNG



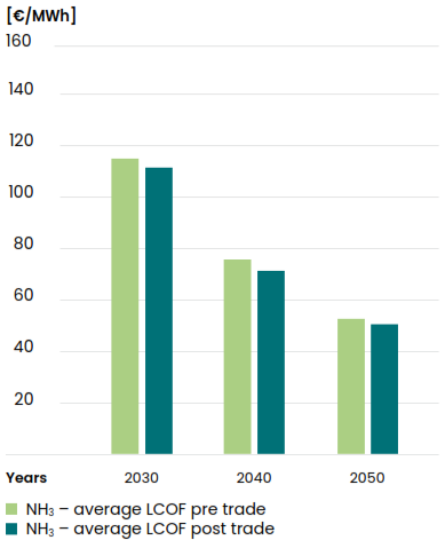
FT-fuels



Methanol



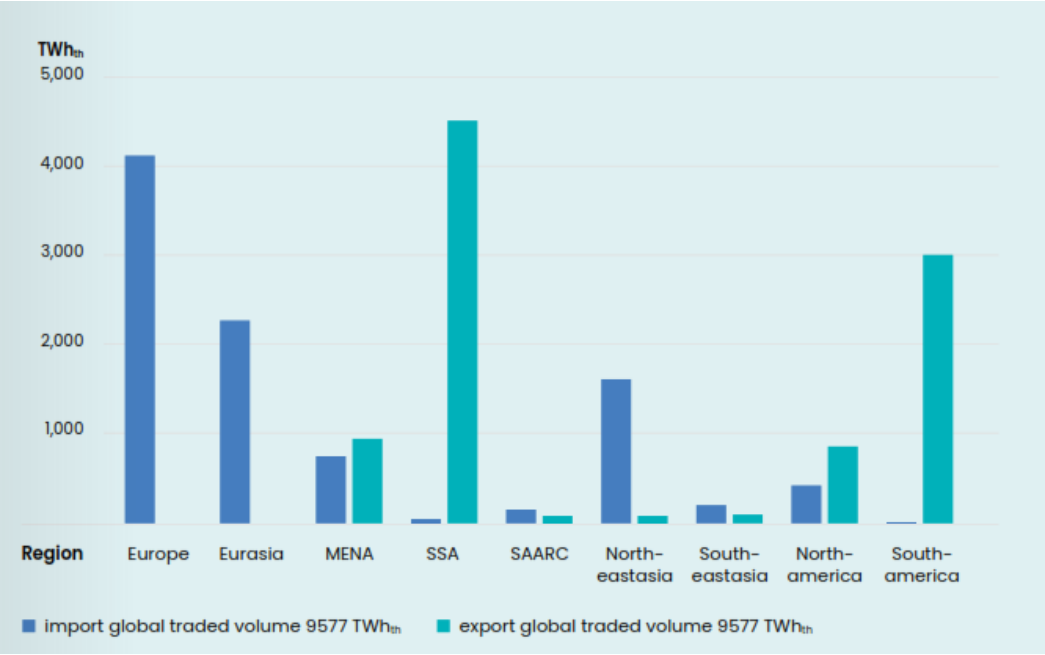
Ammonia



LUT University

Trade streams of powerfuels emerge globally in a cost-optimised scenario

Global trading volumes of powerfuels in 2050



Main importers and exporters

Importers mainly reside in the northern hemisphere.

Exporters mainly reside in the sunbelt region.

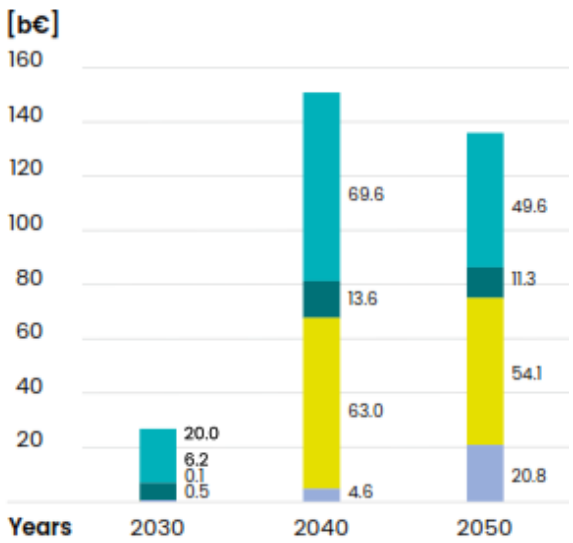
Some regions are importers and exporters, such as North America (Mexico exporting, Canada importing).

Relative reduction in trade streams volumes compared to fossil fuels today

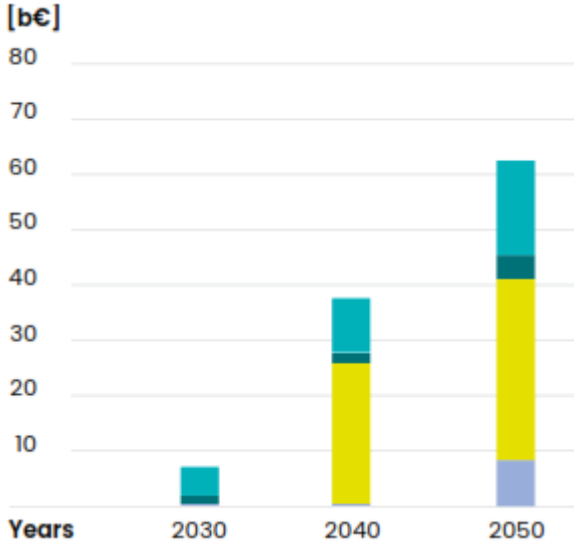
30% - 42%

Global trade results in significant cost savings compared to a self-supply scenario

Global cost reductions



Cost reductions in Europe



Legend

- SNG
- FT-fuels
- Hydrogen
- RE-Ammonia
- RE-Methanol

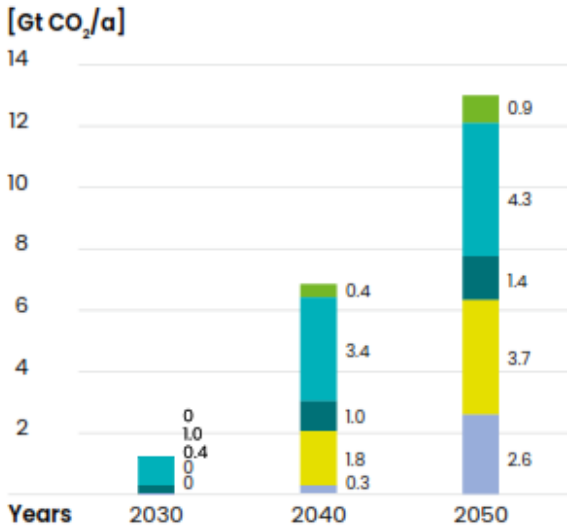
Max. cost reduction

15% - 30%

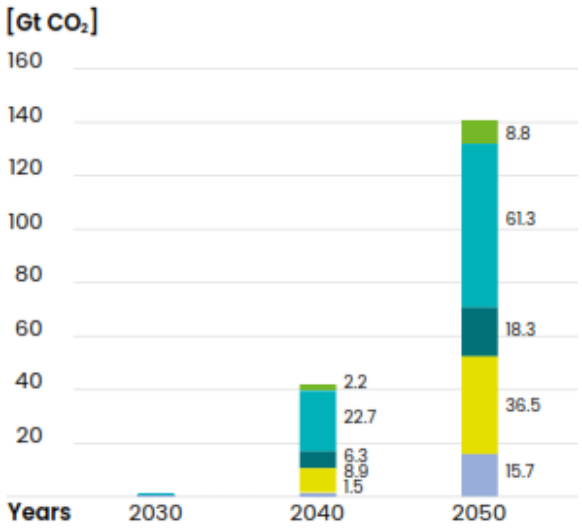
In European countries

A scenario without powerfuels would result in significant amounts of additional CO_2 emissions

Global **yearly** CO_2 avoidance



Global **cumulative** CO_2 avoidance



Legend

SNG	RE-Ammonia
FT-fuels	RE-Methanol
Hydrogen	RE-Naphtha

Cumulative CO_2 emissions avoidance vs. current baseline

140 Gt CO_2

General Conclusions and Assessment from the perspective of the German Energy Agency

dena German Energy Agency

Insights

- **Significant contribution** for carbon neutral system and climate mitigation
- Importance of **sustainable CO_2**
- Global powerfuels **trade lowers cost**
- Powerfuels markets are **more diverse** than fossil markets
- **Investment** needs are comparable to current O&G upstream investments

Recommendations

Global energy / industry bodies

- **Coordinate** on standardisation, funding, policy and regulation

National Governments

- **Evolve ‚H2 strategies'** and define own position in global markets

Oil & Gas industry

- Develop aspiring **transition strategy** and viable transformation pathways
- Divert upstream **investments**

LUT University

STRATEGY & PROJECT TEAM – Contact us

Strategic Guidance

Andreas Kuhlann
Dena Chief Executive, Speaker of the Alliance

Christoph Jugel
Director, Energy Systems

Stefan Siegemund
Director, Sustainable Mobility & Altern. Energy Sources

Project Team

Kilian Crone
Team Lead
+49 (0)30 66 777 - 732
crone@dena.de

Christoph Menzel
Expert
+49 (0)30 66 777 - 129
menzel@dena.de

Matteo Micheli
Expert
+49 (0)30 66 777 - 353
micheli@dena.de

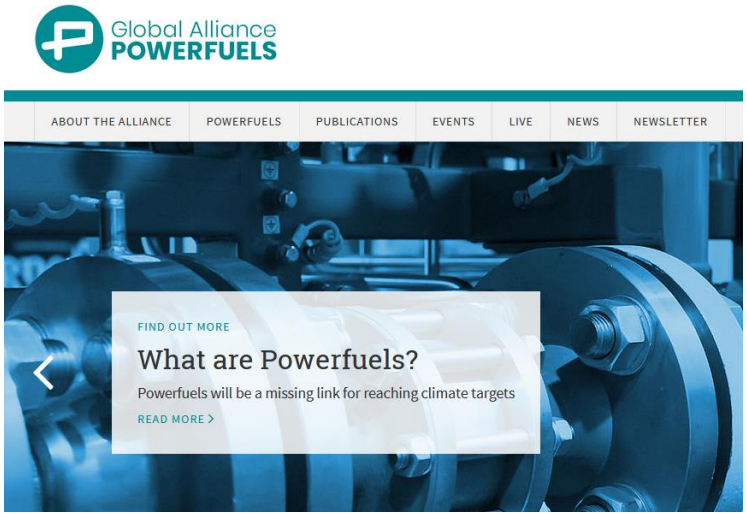
Johanna Friese
Expert
+49 (0)30 66 777 - 108
friese@dena.de

Hannes Salomon
Expert
+49 (0)30 66 777 - 140
salomon@dena.de

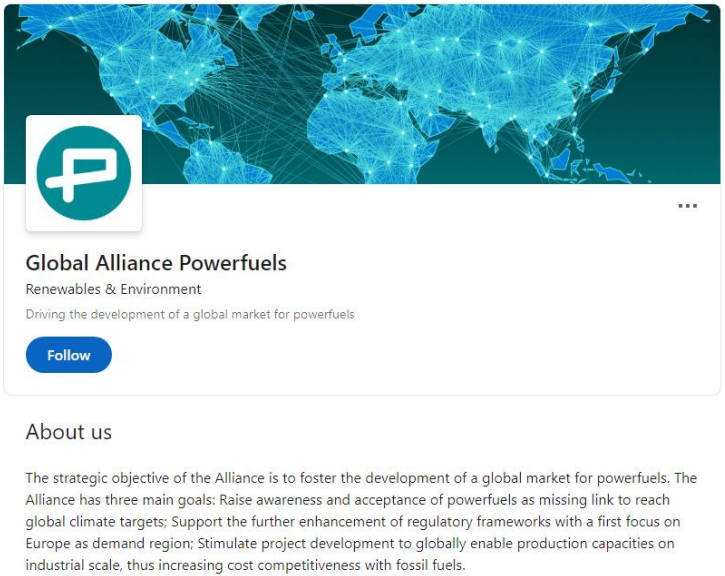
Friederike Altgelt
Expert
+49 (0)30 66 777 - 160
altgelt@dena.de

Find us online

Website



LinkedIn



Thank you for your attention!